

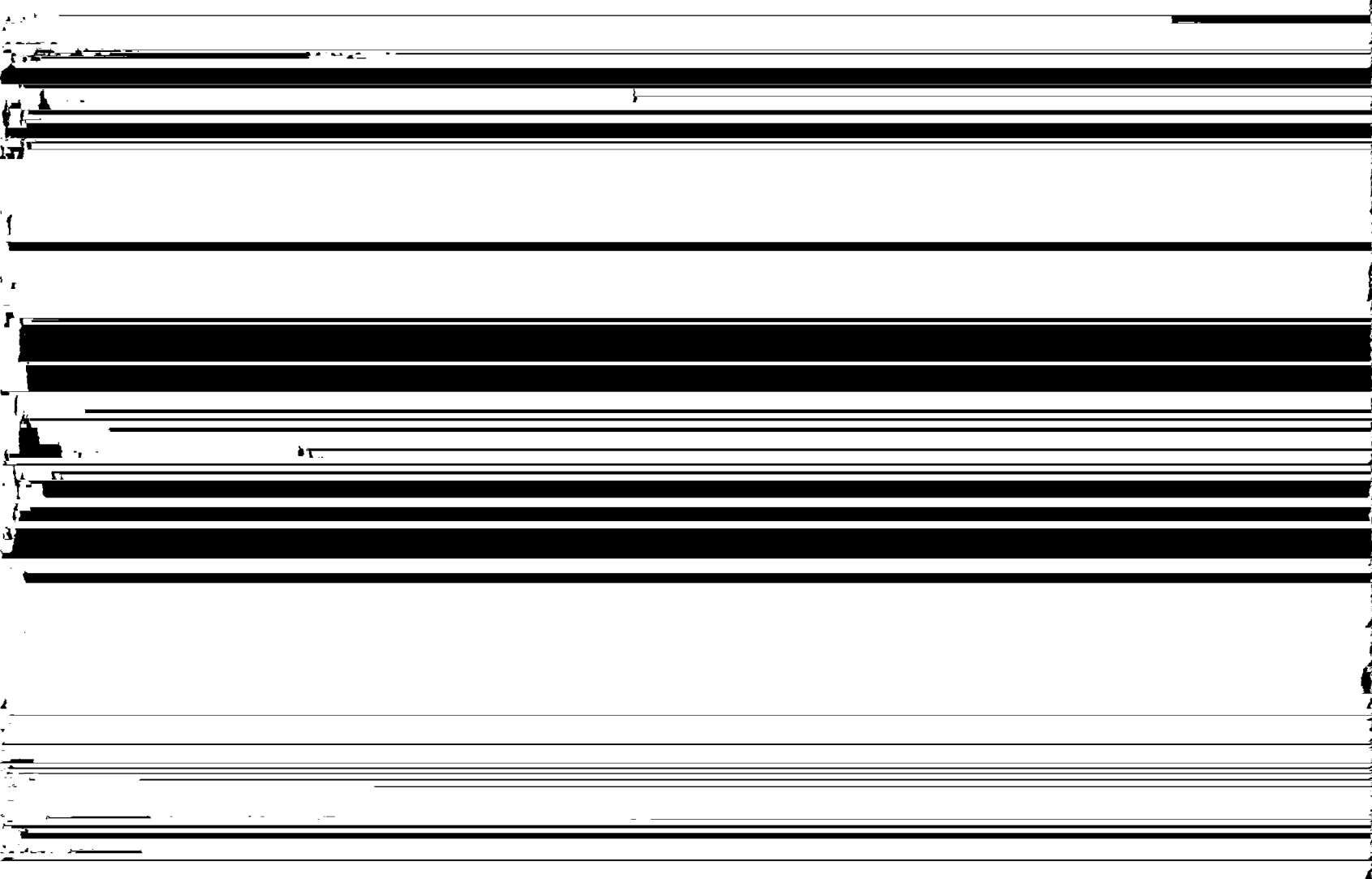
14.3.4.8 Co-Channel Interference into NTSC

Narrow-MUSE performed significantly better than the digital systems for ATV-into-NTSC co-channel interference. All digital systems required about the same signal level to cause co-channel interference into NTSC. (See Figure 14-3.)

14.3.4.9 Adjacent-Channel Interference

Narrow-MUSE performed significantly better than the digital systems on lower adjacent-channel ATV-into-NTSC interference by causing the least interference.

Among the digital systems, DSC-HDTV performed best in rejecting ATV-into-ATV and NTSC-into-ATV adjacent-channel interference. DigiCipher and CCDC caused the least upper adjacent-channel ATV-into-NTSC interference. DSC-HDTV, AD-HDTV and CCDC



14.3.4.13 Power

14.3.4.13.1 Peak-to-Average Power Ratio

The ratios of peak-to-average power for the digital modulation schemes are listed below:

	<u>DigiCipher</u>	<u>DSC-HDTV</u>	<u>AD-HDTV</u>	<u>CCDC</u>
99% of time	4.8 dB	6.3 dB	< 6 dB	< 5.2 dB
99.9% of time	< 6 dB	7.6 dB	< 6.7 dB	< 6.2 dB

The peak-to-average power ratios of DigiCipher and CCDC were judged significantly superior among the digital systems.

14.3.4.13.2 Average ERP

The maximum average ERP for each digital system required to achieve ATV noise limited coverage comparable to NTSC Grade B coverage is listed below:

DigiCipher	38.23 dBk
DSC-HDTV	38.25 dBk
AD-HDTV	40.42 dBk
CCDC	37.66 dBk

It is noted that AD-HDTV required significantly more average ERP than the other systems.

14.3.4.14 Multiple Impairments

The broadcast portion of this test determined POA (which needed only to be a "recognizable" image, not a "watchable" one) under different conditions of random noise and co-channel impairments. The test results show that DSC-HDTV could acquire signal under the worst combination of these impairments, with AD-HDTV very close in performance. DigiCipher and CCDC required a significantly more favorable combination of conditions for signal acquisition.

The cable portion of this test measured TOV under different combinations of random noise and composite triple beat. The test results show that DigiCipher, DSC-HDTV, and AD-HDTV exhibited better performance than CCDC. All digital ATV systems, however, are expected to operate with adequate margins to noise and CTB on existing cable systems designed for carriage of NTSC signals for the nominal ATV power levels tested.

14.3.4.15 Threshold Characteristics

Narrow-MUSE, as expected from its analog signal format, exhibited gradual degradation of image quality with decreasing C/N. All of the digital systems had sharp thresholds, with image quality degrading from TOV to POU over less than a 2 dB change in C/N. Based on certification documents, this performance was expected for DigiCipher and CCDC. The claimed gradual thresholds of DSC-HDTV and AD-HDTV were judged to have utility only for short, temporary, and infrequent signal fading. The actual values of TOV for each system are contained elsewhere in the report.

Audio threshold performance was also characterized. For all of the digital systems, there was no evidence that audio failed before the accompanying video.

14.3.5 Transmission Robustness Findings

1. A variety of different modulation and signal formats was evaluated. In general, the analysis conducted by the Advisory Committee clearly indicates that an all-digital approach is important in satisfying the selection criteria. Of the four digital transmission systems tested, the Special Panel was unable to recommend a single system.
2. Among the digital systems, both sharp and claimed gradual thresholds were tested. No video performance advantages were found in the forms of gradual signal degradation tested.
3. It is desirable to maintain audio service during momentary disruptions in the picture.
4. The four digital systems tested provided adequate levels of operating margin with respect to composite second and third order impairments.
5. Special attention will need to be paid to the final design of tuners in ATV receivers to achieve immunity to typical levels of phase noise and residual frequency modulation. Although the digital systems performed better, as a class, than the Narrow-MUSE system, none performed adequately for typical levels of these impairments in conventional cable equipment.
6. Careful tuner design is required to assure the acquisition of signals that are offset from their nominal assigned frequencies. As tested, three of the digital systems achieved acceptable performance.
7. While three of the digital ATV systems tested exhibited channel change performance close to that required, none demonstrated optimal performance. Current television viewers expect channel change to be completed nearly instantaneously. Minimizing

consumer dissatisfaction with ATV service will require similar performance, certainly well below one second.

8. While the subjective quality tests of cable distribution indicated no degradation, the transmission conditions simulated were not representative of a wide range of real-world cable television plant. Only the field tests will provide final data regarding cable transmission performance.
9. DigiCipher's ability to reject an undesired adjacent or second adjacent signal was significantly worse than the other systems. The proponent has identified an improvement in the system's IF filter which should be verified.
10. Taboo and adjacent-channel performance are dependent on tuner and IF selectivity. Important design information can be obtained from the systems' blackbox tuner/IF characteristics. The proponents should submit both the tuner characteristics of the test hardware and their suggestions for minimum tuner performance.
11. Improvements to the transmission system suggested by the digital proponents include better error correction and concealment, improved receiver RF filters, and techniques to reduce transmitter peak power. Each of these improvement categories addresses specific shortcomings cited in the test results.

14.3.6 Scope of Services and Features

Scope of Services and Features considered the need of an ATV system to support features and capabilities beyond those explicit in other selection criteria. The following were considered as a basis of differentiating among the proponent systems: initial use of ancillary data, audio, data, text, captioning, encryption, addressing, low cost receiver, and VCR capability.

All systems provided for data transmission. With respect to data, the AD-HDTV system was judged better than the others because it used a packetized data structure with headers and descriptors that has been determined, in general, to be important to providing system flexibility. With respect to addressing, the AD-HDTV system was considered better than the other digital systems due to its ability to reassign its entire 18.5 Mbits/s to addressing keys.

Low cost receiver and VCR capability did not expose substantive differences among the five systems.

The remaining five features did not show significant differences among the four digital systems, but overall the digital systems ranked better than the Narrow-MUSE system (though the difference was small).

14.3.7 Extensibility

Extensibility considered the ability of a transmission system to incorporate extended functions and future technology advances. The following were considered as a basis of differentiating among the proponent systems; extensibility to: no visible artifacts, studio-quality data rate, higher resolution, VHDTV, UHDTV, and provision for future compression enhancements.

It was concluded that the use of a packetized data structure with universal headers and descriptors provides important flexibility in meeting this selection criteria. For example, if a higher data rate channel is used to distribute programming to television stations, additional packets (with appropriate headers and descriptors) could provide higher quality images for post-production processing.

Overall, the digital systems ranked better than the Narrow-MUSE system; however, there were no significant differences among the digital systems.

14.3.8 Interoperability Considerations

Interoperability considered delivery over alternative media (cable, satellite, packet networks), transcoding (with NTSC, film, and format conversion to other video standards), integration with computers and digital technology, interactive systems, the use of headers/descriptors, and scalability.

Progressive scan and square pixels are important for computer and other image applications. For interoperability with computers, DSC-HDTV and CCDC ranked better than the other systems.

Only AD-HDTV had its final proposal for a packetized data structure and headers and descriptors fully implemented at the time the system was tested by ATTC, and it received the highest rating on these characteristics. All digital system proponents now recognize the importance of a packetized data structure combined with headers and descriptors as a critical enabling concept for ATV flexibility. As cited in the comparative analysis, examples are SMPTE Header/Descriptor, flexible channel reallocation, compatibility with telecommunications and computer networks.

With respect to format conversion, Narrow-Muse does not require conversion to 1125/60, and AD-HDTV's use of MPEG-1 provides the possibility of interoperability with MPEG applications.

The four digital systems were judged better than Narrow-Muse for interoperability with digital technology, NTSC, film, still images, and interactive systems. Note that latency and acquisition time are important for interactive systems, but have not been completely determined.

All five systems were judged suitably interoperable with satellite and cable.

14.3.9 Findings for Scope of Services and Features, Extensibility, and Interoperability Considerations

In consideration of the comparative analysis and the PS/WP4 conclusions in Section 4.4, the following recommendations are offered.

1. The analysis conducted by the Advisory Committee clearly indicates that an all-digital approach is important in satisfying these selection criteria.
2. All four digital proponents have implemented, or now commit to implement, both a flexible packetized data transport structure and universal headers/descriptors. Their design and implementation need to be verified consistent with relevant industry standards and practices and with respect to the ATV selection criteria.
3. DSC-HDTV and CCDC are progressive at 60 Hz and square pixel in format.

development, the Special Panel did not recommend any one of the four excellent systems for adoption as a United States terrestrial ATV transmission standard at that time. Rather, the Special Panel recommended that these four finalist proponents be authorized to implement their improvements as submitted to the Advisory Committee and approved by the Special Panel's Technical Subgroup.

The Special Panel further recommended that the approved system improvements be ready for testing not later than March 15, 1993, and that these improvements be laboratory and field tested as expeditiously as possible. The results of the supplemental tests, along with the already planned field tests, would provide the necessary additional data needed to select a single digital system for recommendation as a United States terrestrial ATV transmission standard.

15. FUTURE WORK

15.1 DEVELOPMENT OF STANDARDS

The Advisory Committee recognizes that detailed technical specifications and disclosures need to be developed and distributed in a timely manner to the affected industries following the selection of a winning ATV system. The Advisory Committee also realized early on in the process that the documentation effort is not within the purview of the Advisory Committee itself. As early as April 1989, SS/WP4 agreed that the working party would not document a standard in the manner of SMPTE or EIA, but rather its role was to recommend a standard documented by others. The Fifth Interim Report of the Advisory Committee stated that development of a completely specified technical standard would be best handled by organizations other than the Advisory Committee, whose principal goal was "to counsel the FCC and proffer a recommendation on the best available ATV system."¹ The Fifth Interim Report expressed confidence that the appropriate organization would volunteer to conduct this assignment.

On June 5, 1992, the Advanced Television Systems Committee (ATSC) filed information with the FCC to outline proposed industry actions to fully document the selected ATV system. ATSC reviewed the areas where documentation of ATV standards is required when the FCC selects the United States terrestrial ATV transmission system. Some areas require joint cooperation among a wide variety of industries while other areas can best be accomplished by individual standard-setting organizations. Following a recommendation on an ATV system by the Advisory Committee, ATSC said it would immediately begin to document standards for that system. This information will be needed by the FCC in adopting an ATV standard.

In addition to documenting the standard for the FCC, ATSC has suggested which portions of the ATV broadcasting system standard should be incorporated into the FCC Rules and which portions should be voluntary and documented by other organizations such as EIA, IEEE, NAB, NCTA and SMPTE. The FCC's Memorandum Opinion and Order/Third Report and Order/Third Further Notice of Proposed Rule Making encouraged the ATSC and its member groups to begin the documentation process as soon as they have sufficient data. It is expected that this plan will be aggressively pursued by the television industry to speed the implementation of ATV service to the public.

¹ Fifth Interim Report of the Advisory Committee on Advanced Television Service, March 24, 1992, page 21.

15.2 FIELD TESTING

Prior to convening of the Advisory Committee to select a system to recommend to the FCC, only laboratory results, both objective and subjective, were available. Field testing of the selected system will follow.

A test plan was developed by the Field Testing Task Force of Systems Subcommittee Working Party Two. Administrative support for the project has been assumed by the Public Broadcasting Service (PBS). With the hiring of a Test Manager in late summer, 1992, detailed planning and budget preparation were begun. An Executive Committee including the manager and representatives from PBS, the Association for Maximum Service Television (MSTV), and CableLabs provides guidance of the effort, and oversight is provided by the Field Test Technical Oversight Committee.²

The estimated cost of the field testing for terrestrial transmission, excluding the substantial contributions of equipment, building and tower, is \$1,200,000. That sum is being provided by the proponents, with the selected system proponent assuming the major share. A building and tower, transmitters, antennas, transmission line, test equipment, field truck, and a translator to be used for interference testing have all been loaned by suppliers of such equipment. A manager and two additional technicians have been hired for installation and operation of the system. In addition to representatives of the system under test, there will be three observers, including one from the FCC. MSTV will provide analysis of the data collected.

The transmitter site is near Charlotte, North Carolina. In addition to the availability of a building and tower for the field testing, the location is well suited for the observations to be made. Both VHF (Channel 6) and UHF (Channel 53) channels were determined to be usable at that location without the likelihood of serious interference to existing television facilities. A variety of terrain conditions are present, ranging from quite level, through rolling to reasonably rugged. In addition, both rural and urban environments can be examined. Since transmission through cable systems is to be studied, as well as terrestrial transmission, the availability of a variety of cable systems is also a requirement. A review of the systems in the Charlotte area was undertaken by CableLabs. The conclusion of the review was that cable systems appropriate for the testing program were available and willing to cooperate.

A comparison will be made of NTSC and ATV reception, both video and audio, at approximately 200 locations. Both objective measurements and subjective evaluations will be

² The Field Test Technical Oversight Committee is chaired by Richard E. Wiley. The Vice Chair is Joel Chaseman. Other members are Wendell Bailey, Alex Best, Jules Cohen, Birney D. Dayton, Irwin Dorros, Alex D. Felker, Joseph Flaherty, Jack Fuhrer, George Hanover, James C. McKinney, Renville H. McMann Jr., Howard Miller, Robert Niles, Michael Rau, Henry Rivera, Andy Setos, Peter Smith, Craig Tanner, and Warren Williamson III. *Ex officio* members are FCC representatives, proponent representatives, Mark Richer and Edmund Williams.

made of the performance of the selected system in a terrestrial transmission environment. In addition, CableLabs will make objective and subjective evaluations at approximately 50 cable drops spread through a number of systems.

The terrestrial transmission observations will be made along selected radials providing a variety of terrain features, and in grid patterns to provide a measure of the consistency of service in both large and small communities. As recommended by the FCC, some smaller clusters of sites will be used also. In addition, partly by taking advantage of the closest Channel 6 NTSC station, and by use of a translator, NTSC/ATV and ATV/ATV interference will be observed.

At the conclusion of the accumulation and analysis of data, a report will be prepared.

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GLOSSARY

Note: the words in this glossary are defined only for the purposes of this report.

Accommodation Percentage: Accommodation percentage is defined as the number of existing NTSC stations expressed as a percentage of the total number of NTSC stations that can each be assigned one additional simulcast ATV channel (independent of the resulting service area).

Adjacent-Channel Interference: Adjacent-channel interference is the interference from a signal in the first channel on either side of the one desired.

Allocation: An allocation is the specification of a frequency band for use by a particular service.

Allotment: An allotment is the designation of a particular channel, or group of channels, to a community.

Assignment: An assignment is the designation of a channel to be used by a particular licensee.

ATEL: Advanced Television Evaluation Laboratory is a testing facility for subjective evaluations of high definition video in Ottawa, Canada, which is sponsored by a consortium which includes the Department of Communication, Communication Research Centre, Tektronix Canada, Canadian Broadcasting Corporation, Leitch Video International, Rogers Engineering, Telesat Canada and Advanced Broadcasting Systems of Canada.

ATM: Asynchrous Transfer Mode is an emerging standard for advanced packet networks that was developed for high-speed data communications.

ATTC: Advanced Television Test Center is the facility in Alexandria, Virginia, which was designed to objectively measure high definition television as well as to collect expert viewer observations and commentary. ATTC is a private, non-profit organization sponsored by broadcasting companies and industry organizations including Capital Cities/ABC Inc., CBS Inc., NBC Inc., PBS, Association of Independent Television Stations (INTV), Association for Maximum Service Television (MSTV), Electronic Industries Association (EIA) and National Association of Broadcasters (NAB).

ATV: Advanced Television.

B-ISDN: Broadband Integrated Services Digital Network is a future high-speed fiber optic network intended to deliver switched audio, video and data.

CCIR Quality Scale: Although there are several internationally-accepted quality scales, the one used in this report is a five-point, five-interval quality scale with continuous ratings in

Coding: Coding is a way to represent information, such as a picture or sound, electrically with a series of discrete (i.e., digital) codes. The goals are to represent information either efficiently (compression) or robustly (transmission and error correction).

Collocation: Collocation, as used in this report, is the employment of transmitter sites by two or more stations within a radius of ten kilometers.

Coverage Area: Coverage area is the area within an NTSC station's Grade B contour without regard to interference from other television stations which may be present. For an ATV station, coverage area is the area contained within the station's noise-limited contour without regard to interference which may be present.

CRC: Cyclic Redundancy Check is a standard error-detection code used to detect bit errors in a block of data.

CSO: Composite Second Orders interference results from the generation of beats between pairs of signals. Processing signals through amplifiers, and other active devices having non-linear characteristics, introduces intermodulation distortions in clusters of beats with an offset of +1.25 MHz relative to the video-carrier frequency. CSO products dominate in single-ended amplifiers.

CTB: Composite Triple Beat interference results from the generation of beats between multiple signals. Processing signals through amplifiers, and other active devices having non-linear characteristics, introduces intermodulation distortions in clusters of beats normally located around the NTSC visual carrier.

dB: "dB" is the abbreviation for "decibel," a logarithmic ratio. When used to specify power ratios, the arithmetic ratios are converted to dB by the formula: $10 \log_{10} P1/P2$. When used to specify voltage ratios, the arithmetic ratios are converted to dB by the formula: $20 \log_{10} V1/V2$.

dBc: "dBc" is a unit of power level in decibels with reference to the power level of the carrier.

dBm: "dBm" is a unit of power level in decibels with reference to a power of one milliwatt. When preceded by a minus sign, dBm represents decibels below one milliwatt.

DCT: Discrete Cosine Transform is the method used in all the digital systems to spatially compress the video signal. DCT separates the signal into a DC component and higher spatial frequency components. The DCT is used in conjunction with motion compensation to further compress the information which changes from frame to frame.

Decimation: Decimation is the process of discarding information, commonly used to refer to reducing the number of video pixels or audio samples.

Digital System: In this report a digital system refers to a video compression and transmission system which includes motion compensation, DCT and the transmission of only digital data.

D/U: Desired-to-undesired signal ratio expressed in dB. D/U is used in this report to indicate a level of impairment.

Entropy Coding: Entropy coding is a statistically-based technique which assigns shorter bit-length codes to the most common values, and longer codes to the least common, as a function of the probabilities of their occurrence.

Error Rate (also called Alpha): The error rate is the level of error one is willing to accept in deciding that a difference between two statistics is real, when in fact the difference is due to chance. The standard rate is 5% or one chance in 20.

Field: In an interlaced-scanning format, a frame consists of a field of even scan lines and a field of odd scan lines captured or displayed at different times. (See Frame.)

Frame: A frame is one complete image in a sequence of images. In video, the frame captures and displays all pixels and lines of an image. In a progressive-scanning format, there is no decomposition into fields. In an interlaced-scanning format, the frame consists of odd and even line fields, captured or displayed at different times, which in combination contain all pixels and lines of an image. The frame rate of a progressive scan format is twice that of an interlace scan format.

Grade B: Grade B is an FCC definition of the generally considered outer limit of NTSC coverage.

GOP: Group of Pictures is the set of pictures in MPEG-1 compression between the intra-frames (I-frames), which are spatially encoded with no motion compensation.

IEC: International Electrotechnical Commission.

Interlaced Scanning: Interlace refers to a video format where spatially adjacent lines are not consecutively captured or displayed. (See Field and Frame.)

ISO: International Organization for Standardization.

JPEG: Joint Photographic Experts Group is an ISO group which has established a compression standard for digital representation of still pictures.

Latency: Latency is the delay between input and output of a system; the largest components are buffer and frame delays.

M-symbol: A symbol is the smallest temporal unit of RF transmission information. M-symbol, or Mega-symbol, is one million symbols.

Minimum Detectable Difference: The smallest difference between two statistics which would be statistically significant. This quantity depends on the standard deviation, the error rate and the sample size (number of measurements).

Moire: This undesired pattern results from the interaction between a desired, regular image pattern and other regular patterns or structures.

Motion Compensation: Motion compensation removes the frame-to-frame redundancy by predicting the picture content of one frame based on proceeding (and/or following) frames.

Motion Compensation Overload: A failure mode of motion compensated systems where the motion estimator range is exceeded, which was tested using a still image panned at increasing horizontal, vertical and diagonal speeds.

Mottling: Mottling is a localized visual artifact characterized by spots or blotches.

MPEG: Moving Pictures Experts Group is an ISO group which establishes standards for digital video.

Outlier: Outliers are data points that are far away from the rest of the data. In evaluating test results, a data point would be considered an outlier if it were separated from the rest of the data by a distance calculated from the 75th and the 25th percentiles.

Packet: A packet is a fixed-length self-contained block of data that includes all relevant header information to allow switching, routing and data recovery.

Pixel: "Pixel" is an abbreviation for "picture element," a spatial light intensity sample with a discrete value on a rectilinear grid. A color pixel is a triplet of values representing either red, green, and blue intensity, or luminance and two color-difference intensity values.

POA: Point of Acquisition is the maximum impairment level (or the D/U in dB) at or below POU at which a system can acquire a signal and display a recognizable image within five seconds, starting from a no-signal, no impairment condition. For all tests, POA was determined by expert observers.

POU: Point of Unusability is the impairment level (or the D/U in dB) where the picture was

Statistically Significant Difference: A difference not likely due to chance is labeled

***Comparative Analysis of
Advanced Television Systems
Record of Test Results***

Submitted to

Advisory Committee on Advanced Television Service

of the

Federal Communications Commission

by the

Advanced Television Evaluation Laboratory

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Communications Research Centre

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ADVANCED TELEVISION EVALUATION LABORATORY

COMPARATIVE ANALYSIS OF ADVANCED TELEVISION SYSTEMS

RECORD OF TEST RESULTS

January 1993

CERTIFICATION:

Certified that, except as noted, the test data reported herein were collected in accordance with strict scientific and engineering standards as dictated by good practice and as set forth in Documents SSWP2-0390 and SSWP2-0124, in ATEL's Test Management and Operations Plan, and in ATEL's Operations Reference Manual.



Representative of Test Laboratory

92.01.23

Date

COMPARATIVE TEST RESULTS

1.0 BACKGROUND

1.1 *ADVANCED TELEVISION EVALUATION LABORATORY*

The Advanced Television Evaluation Laboratory (ATEL) is a facility of the Department of Communications, Government of Canada. Managed by the Communications Research Centre, the ATEL was established to provide the special facilities needed to display pre-recorded video test materials under the rigorously controlled viewing conditions needed for sensitive and reproducible tests of advanced and conventional television systems.

Assessments of terrestrial advanced television systems are supported by the Canadian Broadcasting Corporation, the Communications Research Centre, the Department of Communications, Leitch Video International, Rogers Engineering, Tektronix (Canada), Telesat Canada, and Advanced Broadcasting Systems of Canada. In Canada, assessments of terrestrial advanced television systems are overseen by the sponsors of the project, under the jurisdiction of the Department of Communications; in the United States, the assessments are overseen by the Federal Communications Commission's Advisory Committee on Advanced Television Service, under the jurisdiction of the Federal Communications Commission.

1.2 *PURPOSE OF THIS REPORT*

The Advanced Television Evaluation Laboratory committed to provide the Advisory Committee on Advanced Television Service with a report that compares systems in terms of performance in the tests identified in the generic video subjective test plan (i.e., Document SSWP2-0390). This report presents the results of these comparisons.

In order to be as complete as possible, the report presents Thresholds of Visibility (i.e., TOVs) and Points of Unusability (i.e., POUs) determined by the Advanced Television Test Center and by Cable Television Laboratories in addition to the results of subjective assessments by non-experts conducted by the Advanced Television Evaluation Laboratory.

1.3 *ACKNOWLEDGEMENTS*

The management and staff of the ATEL express their appreciation to Mark Richer, Chairman of SS/WP-2, for his support and guidance. They also express their appreciation to the Advanced Television Test Center and the Cable Television Laboratories for their cooperation and assistance and for the TOV and POU data reported here. And, finally, they express their special appreciation to the representatives of the Japan Broadcasting Corporation (NHK), the American TeleVision Alliance (ATVA), Zenith/AT&T, and the Advanced Television Research Consortium (ATRC) for their cooperation and assistance during the course of testing.

2.0 SUMMARY OF METHODS

2.1 GENERAL COMMENTS

In general, the test methods used were in accordance with those established internationally by the CCIR to provide valid and sensitive indicators of system performance. In Quality Tests, however, established methods were improved to provide results that relate more directly to performance in terms of specific design attributes (see Document SSWP2-0390).

2.2 VIDEO QUALITY

Document SSWP2-0390 identifies 1 Video Quality test. This is as follows:

- **ATV Basic Received Quality.** In this test, viewers judge the quality of material shown alternately in two forms: in the 1125-line studio format and in the test format under ideal reception conditions (i.e., encoded, modulated, demodulated, and decoded, but not subjected to channel impairments). In this test, viewers judge each of the two forms of presentation using the scales shown in ILLUSTRATION 1.

2.3 PLANNING FACTORS/TRANSMISSION ROBUSTNESS

Document SSWP2-0390 identifies 10 tests that examine the off-air transmission performance of the ATV system. These are as follows:

- **Random Noise.** In this test, viewers compare a picture as received at a given signal level for the system under test with the same picture as received at lesser signal levels (i.e., with decreased carrier-to-noise ratios). The viewers judge the visibility and severity of impairment due to different carrier-to-noise ratios.
- **Co-Channel Interference from ATV to ATV.** In this test, viewers compare a picture as received at a given signal level in the system under test, but with no co-channel interference, with the same picture as received at the same signal level, but with a measured amount of co-channel interference from the system tested (i.e., with a decreased desired-to-undesired ratio). The viewers judge the visibility and severity of impairment due to different desired-to-undesired ratios.
- **Lower-Adjacent Channel Interference from ATV to ATV.** This test is similar to that for co-channel interference from ATV to ATV, but uses lower-adjacent channel interference from the system under test.
- **Upper-Adjacent Channel Interference from ATV to ATV.** This test is similar to that for co-channel interference from ATV to ATV, but uses upper-adjacent channel interference from the system under test.

- Co-Channel Interference from NTSC to ATV. In this test, viewers compare a picture as received at a given signal level in the system under test, but with no co-channel interference, with the same picture as received at the same signal level, but with a measured amount of co-channel interference from NTSC (i.e., with a decreased desired-to-undesired ratio). The viewers judge the visibility and severity of impairment due to different desired-to-undesired ratios.
- Lower-Adjacent Channel Interference from NTSC to ATV. This test is similar to that for co-channel interference from NTSC to ATV, but uses lower-adjacent channel interference from NTSC.
- Upper-Adjacent Channel Interference from NTSC to ATV. This test is similar to that for co-channel interference from NTSC to ATV, but uses upper-adjacent channel interference from NTSC.
- Co-Channel Interference from ATV to NTSC. In this test, viewers compare a picture as received at a given signal level in NTSC, but with no co-channel interference, with the same picture as received at the same signal level, but with a measured amount of co-channel interference from the system tested (i.e., with a decreased desired-to-undesired ratio). The viewers judge the visibility and severity of impairment due to different desired-to-undesired ratios.
- Lower-Adjacent Channel Interference from ATV to NTSC. This test is similar to that for co-channel interference from ATV to NTSC, but uses lower-adjacent channel interference from the system under test.
- Upper-Adjacent Channel Interference from ATV to NTSC. This test is similar to that for co-channel interference from ATV to NTSC, but uses upper-adjacent channel interference from the system under test.

In these tests, viewers judge the incremental impairment in the second (i.e., impaired) picture using the judgement scale shown in ILLUSTRATION 2.

2.4 INTEROPERABILITY/SUITABILITY FOR CABLE

Document SSWP2-0390 identifies 3 tests that consider suitability for alternate media. These are as follows:

- **ATV Cable Received Quality.** In this test, viewers judge the quality of material shown alternately in two forms: in the test format under ideal reception conditions and in the test format under more typical cable reception conditions (i.e., encoded, modulated, transmitted by a cable distribution system, demodulated, and decoded). In this test, viewers judge each of the two forms of presentation using the scales shown in ILLUSTRATION 1.

- **ATV Fiber Received Quality.** In this test, viewers judge the quality of material shown alternately in two forms: in the test format under ideal reception conditions and in the test format under more typical fiber reception conditions (i.e., encoded, modulated, transmitted by a fiber distribution system, demodulated, and decoded). In this test, viewers judge each of the two forms of presentation using the scales shown in ILLUSTRATION 1.
- **[Cable] Third-Order Intermodulation Distortion.** In this test, viewers compare a picture as received at a given signal level for the system under test, but with no intermodulation distortion, with the same picture as received at the same signal level, but with a measured amount of third-order intermodulation distortion from NTSC (i.e., with a decreased desired-to-undesired ratio). The viewers judge the visibility and severity of impairment due to different desired-to-undesired ratios. In this test, viewers judge the incremental impairment in the second (i.e., impaired) picture using the judgement scale shown in ILLUSTRATION 2.

3.0 DESCRIPTION OF RESULTS

3.1 GENERAL COMMENTS

The results of subjective assessments by non-expert viewers are summarized in tabular form in this section of the report. The TABLES present the mean performances of the systems as measured and, as appropriate, the statistical rankings of the systems in terms of measured performance. Statistical rankings were derived by Analysis of Variance with *post hoc* comparisons using the technique developed by Scheffé.

Results from assessments by non-expert viewers are presented in full in the FIGURES. These FIGURES also present Thresholds of Visibility (i.e., TOVs) and Points of Unusability (i.e., POUs) determined by the Advanced Television Test Center and by Cable Television Laboratories. NOTE: For some impairment and interference tests, TOV values also are provided in the TABLES.

3.2 VIDEO QUALITY

The Advisory Committee considers video quality under one selection criterion: Audio/Video Quality. The data used to measure video quality are those summarized here, as supplemented by expert observations.

The results of assessments of Basic Received Quality are summarized by type (i.e., origin) of test material in TABLE 1. For the graphic material, however, the still and the motion sequence are presented separately, as analyses by the Advisory Committee have tended to report the data from these pictures separately.

For Basic Received Quality, TABLE 1 shows that, with camera-originated motion sequences, AD-HDTV and DigiCipher performed better than the other systems. With material transferred from film (*via camera*), DigiCipher and AD-HDTV performed best; Narrow-MUSE performed next best, followed by CCDC and DSC-HDTV. With the graphic motion sequence, CCDC and DSC-HDTV performed best; AD-HDTV and DigiCipher performed next best, followed by Narrow-MUSE. With material scanned from stills¹ and with the graphic still, the systems did not differ in overall performance.

The reader is encouraged to examine FIGURE 1, which presents the judged quality of the systems for each of the 23 segments of test material. The FIGURE gives a fuller appreciation of the performances of the systems and may be useful in identifying areas in which systems could be improved. The reader further is encouraged to examine FIGURE 14. The FIGURE presents, for each segment of material, the judged quality of the 1125-line studio system used as reference in the tests of Basic Received Quality. As the FIGURE shows, judgements of the reference maintain a reasonable consistency across all systems.

TABLE 1

ATV BASIC RECEIVED QUALITY

D: quality of system *minus* quality of reference (if positive, system exceeds studio quality);
R: statistical ranking of systems (lower values are better)

	STILLS [S01-S10]	CAMERA [M01-M10]	FILM [M17-M20]	GRAPHIC [S14]	GRAPHIC [M16]
N-MUSE	D: -9.43 R: 3.0	D: -20.71 R: 4.0	D: -14.69 R: 3.0	D: +23.82 R: 3.0	D: -24.45 R: 5.0
DigiCipher	D: -5.81 R: 3.0	D: -7.03 R: 1.5	D: -4.74 R: 1.5	D: +11.85 R: 3.0	D: -8.85 R: 3.5
DSC-HDTV	D: -9.20 R: 3.0	D: -23.42 ² R: 4.0	D: -24.31 ² R: 4.5	D: +14.77 R: 3.0	D: +13.49 R: 1.5
AD-HDTV	D: -6.61 R: 3.0	D: -5.71 R: 1.5	D: -5.41 R: 1.5	D: +18.92 R: 3.0	D: -7.50 R: 3.5
CCDC	D: -10.83 R: 3.0	D: -27.97 ² R: 4.0	D: -22.39 ² R: 4.5	D: +28.44 R: 3.0	D: +17.09 R: 1.5

NOTES:

1. In accordance with standard statistical practice, ties share the average of the ranks they otherwise would be assigned (e.g., 2 cases tied for first place would be assigned ranks of 1.5, the average of ranks 1 and 2).
2. The camera used to prepare source material for DSC-HDTV and CCDC in this part of the test introduced high levels of random noise as well as horizontally coherent noise. These may have affected the performances of DSC-HDTV and CCDC in this part of the test.

¹ When the performances of the systems are examined for each still individually, *post-hoc* analyses indicate that CCDC exhibited lower performance than the other systems for S05, S07, and S09 and that DSC-HDTV exhibited lower performance than the other systems for S01.